PROJECT 630-88

OPERATING AND INSTRUCTION MANUAL

Velonex

PULSE GENERATOR MODEL 220

VELONEX
DIV. OF PULSE ENGINEERING, INC.
560 Robert Avenue
Santa Clara, California

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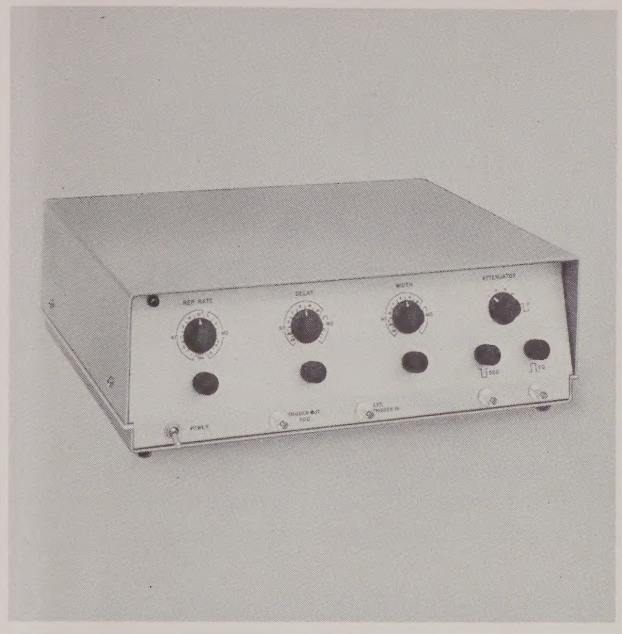

A COMPLETELY TRANSISTORIZED GENERAL PURPOSE PULSE GENERATOR THAT OFFERS A RELIABLE, LOW IMPEDANCE SOURCE OF NEGATIVE AND POSITIVE OUTPUT PULSES—

SIMULTANEOUSLY AVAILABLE AND INDEPENDENTLY VARIABLE. DROOPLESS PULSE, FAST RISE AND FALL TIMES. A COOL CHASSIS. MINIMUM MAINTENANCE. NO D.C. OUTPUT IN ANY MODE OF OPERATION.

Price: $1180 f.o.b. Santa Clara, California.

SUMMARY OF FEATURES

Low source impedance produces completely droopless pulse.

No D.C. output level in any mode of operation.

70% duty cycle.

Positively current limited. Terminals may be shorted together indefinitely without damage to the instrument.

500 milliamps of current at 25v at 5 ohm source impedance, positively protected against accidental shorting of the output terminal.

Excellent output wave form:

Fast rise time—typically 10 ns, 12 ns. max.

May be driven externally by a low voltage source, such as 1 v rms sine wave.

Positive external output sync voltage of 5 v, 50 ns in any mode of operation into 50 ohms.

Designed for reliability and fully transistorized for minimum maintenance.

A cool chassis—no fans or other ventilation devices required.

No internal adjustments necessary to obtain a droopless pulse.

The Velonex Model 220 is a transistorized, general purpose pulse generator, suitable for a wide range of application for pulse circuit development and operation. Reliable low impedance source of positive (5Ω) and negative (50Ω) output pulses simultaneously available and independently variable, offering a wide range of pulse widths with extremely fast rise times. Fast rise and fall times are assured without time or amplitude jitter.

Plug-in output transformers for impedance matching, mixing, step-up or step-down are available.

SPECIFICATIONS

	100 cps to 5mc
Rise time	10ns typical; 12ns max.
Amplitude	simultaneous output
Positive (+)	3-25V, 0-500ma, 5 ohm source (25V into 50Ω)
Negative (−)	0-20V, 0-250 ma, 50 ohm source (10V into 50Ω)
Pulse width	50ns through 1.0ms (9 steps plus vernier)
Pulse delay	0 through 1.0ms (9 steps plus vernier)
Duty factor	70%, no base line shift with duty cycle variation
SYNC input	1V rms sine wave
SYNC output	5V., 50 ns into 50 ohm
Weight	20 lbs.
Cabinet	17" wide, 13" deep, 5¾" high
Power requirements	115V AC 60 cycles 60 watts

Short circuit output protection: terminals may be shorted together indefinitely.

Additional options:

Model 101 50 ohm Attenuator	$45.00
Model 102 Rise and Fall Time Control	$35.00
Model 103 Accessory Kit	$170.00
Model 104 Plug-in Impedance Matching Output Transformers	$27.00
Model 105 Single Pulse Generator	$62.50

1/1963 Data subject to change without notice.

velonex / a division of pulse engineering, inc. / 560 robert avenue, santa clara, california / 244-7370 / twx 408-287-6570

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PULSE GENERATOR MODEL 220 GENERAL

The Velonex Pulse Generator Model 220 produced by the Velonex division of Pulse Engineering is a transistorized general purpose generator produced for use as a production and laboratory instrument and where reliability, ease of operation and modern performance are necessary. Matching accessories and additional Velonex instruments provide the pulse circuit Engineer with a means of testing, circuit development, and original equipment installation.

Years of service and continued customer interest assure you, the user, of economy of operation and maintenance. We are always interested in customer comments and suggestions regarding application, use, or modification.

On receipt of your instrument, unpack carefully, noting the condition of the shipping container. In the event of damage please follow procedure noted "Claim for Damage in Shipment."

Once unpacked, the instrument should be tested to the specification using a 100 ohm 2 watt non-inductive resistor as a load.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Velonex, Div. of Pulse Engineering, Inc., warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Transistors, diodes, tubes and fuses are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Velonex instruments should be prepaid. The instruments should be packed in a strong exterior container and surrounded by two inches of Tufflex U-200 or similar shock-absorbing material.

VELONEX, a Division of
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VELONEX

MODEL 220
APPLICATION NOTE # 2

1. CAUTION: Use diode network Model 110 plug-in when driving inductors, unloaded pulse transformers or large capacitors.

Most inductors and non-terminated transformers will oscillate at pulse repetition rates within the VELONEX Model 220 operating range. The voltage oscillations from these inductors will exceed the peak inverse voltage, (P.I.V.) rating of the output transistors, particularly at high duty cycle. This type of operation will short or open output transistors T21, T22, and T23.

The VELONEX Model 110 diode network will increase rise time by approximately 1 nanosecond but will protect the Model 220 Pulse Generator from high peak inverse voltages when connected to inductors or improperly terminated pulse transformers and large capacitors.

2. CAUTION: Do not exceed the 70% duty cycle rating for the VELONEX 220 beyond 1 MC or with the output shorted. Extended operation under conditions of shorted output, high rep. rate and exceeding 70% duty cycle may cause a failure of output transistors T21, T22, and T23.

3. CAUTION: Do not couple direct current into the output terminals of the VELONEX 220 Generator. If the DC coupling into the generator from the driven circuit will exceed 50 mils at 6 volts, use a Model 104 coupling transformer or blocking capacitor.

December, 1963

PULSE OUTPUT

Both positive and negative output pulses are available simultaneously from the two type B and C connectors. Each has a discreet source impedance.

Positive Output Pulse

The source impedance of the positive output terminal is 5 Ω and the output voltage may be adjusted from 3 to 25 volts into a 50 Ω load while supplying up to 500 MA of current. The positive pulse output is current limited so that no combination of repetition rate, duty cycle, pulse width, amplitude or load will allow more than 500 MA of current to flow.

If the setting of panel controls for a low resistance load calls for more than 500 MA, the normal operation of the positive pulse current limit circuit may be noted as a distinct overshoot thus:

The purpose of the 5 Ω source impedance on positive output is to provide a stiff source of droopless pulses and to achieve the high current capability of the VELONEX 220 Generator. Normal operation of the 5 Ω output pulse is to drive a 50 Ω co-axial cable terminated in 50 Ω or if desired, 5 Ω from leads not over 10 inches connected directly to the output jack.

DON'T terminate a length of 50 Ω cable with 5 Ω. If a long length (over 3') of 50 Ω cable is to be driven from the 5 Ω output jack, some increase in overshoot can be expected unless a VELONEX # 101 Attenuator is used.

The 5 Ω output impedance of the Model 220 makes the application of step-up transformers very practical. It is possible to connect Model 104 transformers and step-up the output of the VELONEX 220 to two or three times the normal output voltage with little deterioration in the wave form.

OUTPUT: NEGATIVE PULSE

The source impedance of the negative output pulse is a constant 50 Ω and the output amplitude may be varied from 0 to 20 volts or 0 to 10 volts into 50 Ω. It will supply load current of 200 MA.

The negative output is inherently current limited so that combinations of repetition rate, duty cycle, pulse width, amplitude and load will not allow more than 200 MA of current to be drawn.

ACCESSORIES

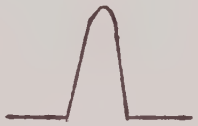
Output versatility of your 220 Generator may be further increased by use of: a) Inverting transformers, b) Voltage step-up transformers, c) Impedance matching transformers, d) Rise & Fall time controls, e) Isolation output transformers to 10 KV.

See 'Accessories' for detailed descriptions.

OUTPUT: SYNC

The output from the sync output connector is a positive pulse of 5 volts, 50 nanoseconds in width from an emitter follower circuit which will provide 5 volts into a 50 Ω terminated cable. This sync output voltage is also available when the pulse generator is driven from an external source.

Normal wave form is:



Note that sync problems are minimized with a solid pulse of this type. The output connector is a series 31 BNC connector. Adapters, cables with connectors, etc., are part of the VELONEX accessory kit Model 103.

REPETITION RATE CONTROL

The controls on the extreme left hand side of the instrument control the repetition rate from 100pps to 5,000,000pps in nine (9) steps plus a vernier. Any frequency may be selected provided the 70% duty factor is not exceeded. No damage will result with duty factors greater than 70%. See 'Duty Factor' description.

PULSE DELAY CONTROL

The pulse delay controls provide a convenient means of delaying the output pulse from 0 to 1 millisecond in nine distinct steps with a vernier control for precise setting. Interaction with other controls will not occur unless the duty factor of 70% is exceeded.

PULSE WIDTH CONTROL

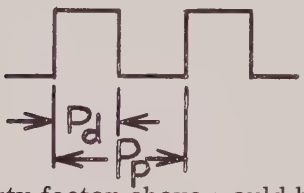
The pulse width control provides an adjustment for varying the pulse width from 50 nanoseconds (.050usec) through one (1) millisecond. This control is also provided with a vernier for precise setting. Again control interactions will not occur within the limits of the 70% duty factor.

INPUT: SYNC

The Velonex Model 220 Pulse Generator has unusual external drive capabilities and may be driven by as little as a one (1) volt rms sine wave or any negative or positive going pulse up to 30 volts peak. Any frequency to 5mc is acceptable with the normal 70% duty factor limitation. Input impedance: 360Ω in series with 1uf.

DUTY FACTOR

Duty factor is defined as the ratio of pulse duration to pulse period.



P_d — Pulse duration

P_p — Pulse period

The duty factor above would be 70%. Model 220 Pulse Generator may be modified on special order for a 90% duty factor for limited pulse widths and repetition rates. Exceeding the 70% duty factor will cause wave form distortion, unequal pulse widths and delay, but the instrument will not be harmed.

THEORY OF OPERATION

BLOCK DIAGRAM

A simplified block diagram of the Model 220 pulse generator is shown in Fig. 1. The diagram has been laid out in functional blocks without consideration for the amount of circuitry required to realize the blocks. Detailed circuit schematics of the individual blocks appear later in this manual, but may be conveniently referred to at any point in the discussion to follow.

The repetition rate of the instrument is controlled either by an internal free-running multi-vibrator, or by an external oscillator. In either case, the input wave-form is impressed upon a Schmitt trigger for conversion to a fixed amplitude, fast rise-time pulse. The output of the Schmitt trigger branches to a blocking oscillator and to a delay one-shot. The blocking oscillator generates a pulse of fixed width, (50 nanoseconds) and fixed amplitude. The inductive overshoot which occurs at the trailing edge of this pulse is passed through an emitter follower and delivered to the trigger output terminal at a 50 ohm impedance level. The delay one-shot, which is also driven by the Schmitt trigger, has a minimum pulse width of 50 nanoseconds, corresponding to the 50 nanoseconds width of the blocking oscillator. In this way, zero delay time can be obtained between the trigger output and either pulse output. The output of the delay one-shot is differentiated and the trailing edge used to trigger the pulse width one-shot. The pulse width one-shot is directly coupled to both the positive pulse amplifier and the negative pulse amplifier. In the case of the positive pulse output, the

output amplitude is controlled entirely by varying the supply voltage to the output stages. In addition, a 1/2 amp current limiter is employed to prevent damage to the output transistors from accidental shorting of the output terminals. The output amplitude of the negative pulse is controlled by a 50 ohm attenuator in conjunction with a vernier on the power supply to the final stage.

REPETITION RATE CONTROL

MULTI-VIBRATOR

The internal frequency source of the Velonex Model 220 is a free-running multi-vibrator of the emitter coupled variety. A circuit diagram of the multi-vibrator is shown on sheet #1. The frequency of oscillation in this circuit is determined by the timing capacitor connected between the emitter of T-1 and T-2 and the magnitude of the current source in each emitter leg. The one stable state, transistor T-1 is conducting and transistor T-2 is biased off. The current sources are both extracting current from the emitter of T-1. In this case the current flowing through the timing capacitor, produces a voltage drop across it in the direction to turn T-2 on. As T-2 turns on, it robs some of the available current from T-1, resulting in a voltage rise at the collector of T-1 and at the base of T-2 (since they are direct coupled). The action is thus regenerative resulting in a rapid turn-on of T-2 and a rapid turn-off of T-1. When T-2 is on and T-1 is off, the current flowing in the timing capacitor produces a voltage in the direction to turn T-1 on. Again the change-over action takes place regeneratively with very fast transition times.

A vernier for the operating frequency is provided by the 50 k potentiometer (R7) in the emitter of T-2. This potentiometer controls the magnitude of the current source in the leg. Major steps in output frequency are obtained by switching-in various values of timing capacitance (C3-C11). In order to prevent loading effects from interacting with the timing networks, the output is buffered to the Schmitt trigger via emitter follower T-3.

SCHMITT TRIGGER

The Schmitt trigger shown on Sheet #2 is conventional. The circuit is arranged such that transistor T-4 is normally non-conducting and transistor T-5 is normally conducting. A positive going input, either from the multi-vibrator or from an external source, will turn T-4 on and T-5 off. The transition is rapid, regardless of the input wavefront, because of the regenerative coupling between the collector of T-4 and the base of T-5, and because of the commonly shared emitter resistor. A negative going wavefront at the input results in a restoration of the original states of T-4 and T-5. The resulting square output pulse is buffered to the blocking oscillator and delay one-shot via emitter follower T-6.

EXTERNAL TRIGGER CIRCUIT

Referring to Sheet #3, a blocking oscillator is employed as a very efficient means of matching the minimum delay of the delay one-shot with the onset of the external trigger pulse. The positive pulse from the Schmitt trigger is differentiated at the input of T-7 to fire the BO. A special low inductance transformer (Pulse Engineering) is used to provide regenerative coupling to the emitter of T-7 and to provide the fixed time-out period of 50 nanoseconds. Since no clamp diode is used at the collector of T-7, the backswing of the transformer is substantial. The positive portion of the backswing is passed by diode D-2 to the emitter follower T-8. The low output impedance of T-8 is nominally matched to a 50 ohm output cable by the 39 ohm resistor at T-8 emitter.

PULSE DELAY AND PULSE WIDTH CONTROLS

TIMING ONE-SHOTS

The delay one-shot and pulse width one-shot in this instrument use identical circuits. A circuit diagram of the one-shot is shown in Sheet #4. The operation of this circuit is controlled primarily by transistors T-10 and T-12. The emitters of these 2 transistors are fed in common by a current source of 25 milliamps. Transistor T-12 is normally conducting because its base is held positive, in comparison to the base of T-10 by the forward voltage drop in diode D-6. An input pulse is differentiated and the positive spike used to turn transistor T-10, resulting in a negative step at T-10 collector. Emitter follower T-11 transmits this step through the timing capacitor to the base of T-12. The magnitude of this step is determined by the clamping potential at the emitter of T-9, which limits the excursion at the collector of T-10 when D-5 conducts. The potential at D-6 and the base of T-12 recovers towards ground as the timing capacitor recharges through the 5 k potentiometer (R36) and the 1.5 K (R37) resistor. When the potential at the base of T-12 exceeds that at the base of T-10, the constant current of 25 milliamps is switched back into T-12, thus restoring the circuit to its normal state. The time-out period of the quasi stable state is determined by the magnitude of the timing capacitors, (which provide the range switching), the charging rate (which is controlled by the 5 k vernier), and the magnitude of the timing step (which is determined by the potential at the base of T-9.) Both a low impedance negative pulse and a low impedance positive pulse are provided by transistor T-13. The pulse delay one-shot Sheet #4 is used to drive the pulse width one-shot, Sheet #5, the second circuit is triggered on the trailing edge of the negative pulse. The pulse width one-shot circuit drives both the positive and negative pulse amplifiers. The positive and negative outputs of the pulse width one-shot are both used as shown in the block diagram of Fig. 1. The pulse width one-shot Sheet #5 operates identically to the pulse delay one-shot.

OUTPUT CIRCUITRY

POSITIVE PULSE AMPLIFIER

A circuit diagram of the positive pulse amplifier is shown on Sheet #6. The input to the amplifier is already of the correct width and proper delay. It is only necessary for the amplifier to provide proper output amplitude and impedance. The input pulse is capacitively coupled to the base of T-19 which is an emitter follower. Transistor T-19, in turn, drives T-20, which is an inverting and squaring amplifier. Transistor T-20, in turn, drives transistor T-21 which controls the output amplitude and is primarily responsible for the rapid rise and fall times at the output. The output amplitude is controlled by varying the potential to which the collector load of T-21 is returned. In this case the potential can be varied from + 3 volts to + 25 volts. As the supply potential is varied, the collector load of T-21 is also varied by means of a ganged pot (R63 and R116). In this way the collector current of T-21 is maintained at a nearly constant level resulting in nearly constant rise and fall times over the amplitude range. The output is driven by a pair of emitter followers, T-22 and T-23, which are directly connected to the collector of T-21. These transistors provide a very low output impedance (5 ohms or less) with a current capability of 1/2 ampere. With an output impedance this low it is imperative that the output stages be protected from burnout due to an accidental shorting of the terminals. Such protection is afforded by current limiting the variable supply potential which feeds the output stages.

NEGATIVE PULSE AMPLIFIER

The negative pulse amplifier works in the fashion exactly analogous to the positive pulse amplifier. In this case, however, Sheet #7 shows that complementary types of transistors are employed. A few additional differences will also be noted. Because of the reduced current requirements at the output only a single output emitter follower is employed. The voltage supplying the output collectors is not current limited, but the output transistor is protected by the series, 43 ohm resistor. Finally, the 50 ohm source impedance makes it possible to use the 50 ohm attenuator in conjunction with a simplified vernier adjustment on the output supply voltage.

NEGATIVE OUTPUT ATTENUATOR

A constant 50 ohm source impedance is available from the negative output pulse terminals regardless of the attenuator position. Note that the negative output pulse amplitude may be varied from -1/4 volt to -22 volts by switching the attenuator and setting the amplitude control with the vernier.

POWER SUPPLIES

The model 220 pulse generator requires 5 power supplies: + 6 volt, -6 volt, + 30 volt, a positive variable voltage (from 3 to 25 volts with current limiting) and a negative variable voltage (from 6.8 to 22 volts). All supplies are regulated with the exception of the -6 volt supply which employs an active filter circuit. A complete schematic of all supplies is shown in Sheet 8. Notice that trim pot adjustments are present on the + 6 volt and + 30 volt supply.

Trim pot adjustments are made at time of assembly and require only an occasional check and readjustment, as follows:

1. Connect a VTVM to the + 30 volt bus and adjust R105 until + 30 volt $\pm$ 3% is reached.

2. Connect a VTVM to the + 6 volt bus and adjust R111 until + 6 volt $\pm$ 3% is reached.

POWER SUPPLY

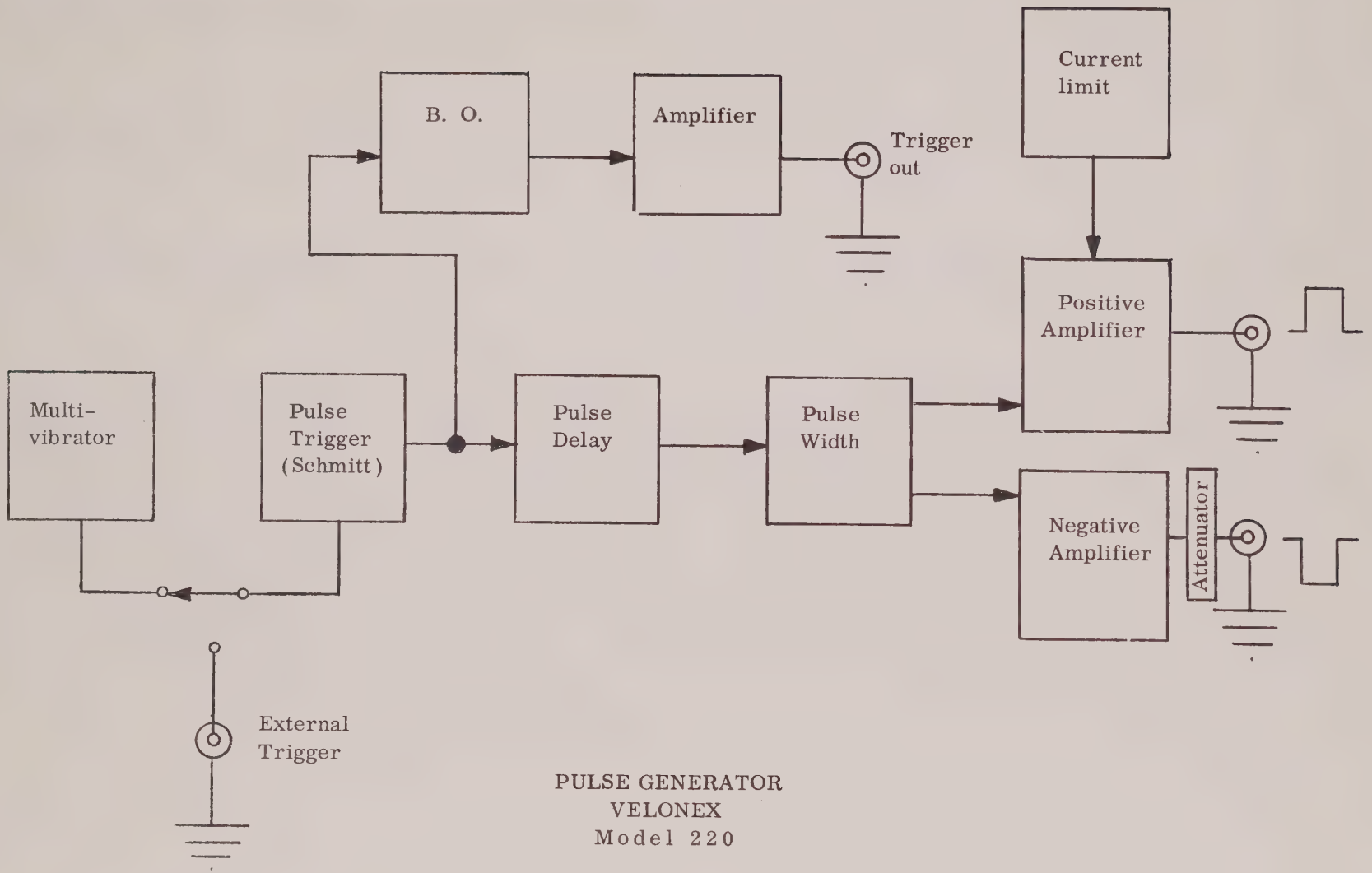
The three regulated supplies all work in basically the same fashion. A full wave rectifier feeds a capacitive input filter to provide the raw d-c voltage. Following the fuse, a series pass transistor provides current to the output capacitor and load. The actual load regulation is obtained from a comparison amplifier. In the +6v supply, for example, a fraction of the output (taken from the arm of R111) is compared with a reference voltage in the emitter of T31. In this case the reference voltage of about 1.2 volts is obtained from the forward drop of two rectifier diodes. If the output voltage drops, T31 tends to turn off, raising the voltage on the base of T34, and providing more drive to transistor T38, the series pass transistor. The additional current thus provided by T38 corrects the low voltage condition.

The +30v and -22v supplies work in exactly the same fashion. In these two, however, actual zener diodes (Z_1 and Z_2) are employed. Diodes D31 and D32, in conjunction with T103 and R107, are used to current limit these two supplies to prevent damage from accidental shorting of the supply rails. Transistor T28 additionally protects the sensitive germanium pulse transistors against over-voltage by delaying the -22v turn-on until the +6v supply has come on.

The -6v supply, though not regulated, employs an active ripple filter. The raw d-c voltage is completely smoothed by R91 and C71. With this voltage as a reference, transistors T35 and T39 provide successively lower impedance at relatively constant voltage. As in all the

supplies, the output impedance at high frequencies is maintained at a low level by the large output capacitance.

The variable positive voltage is taken from the +30volt bus. A constant current source is provided by T40 (which has a constant voltage base reference and fixed emitter resistance). The constant 500ma of current is passed through D16 to three shunt regulating transistors. These transistors maintain the voltage established at the arm of R116 by absorbing any current not consumed at T40-C. If the current demanded by the load is greater than the 500ma available, diode D16 turns off, and the output changes almost instantaneously from constant voltage to constant current operation. In this way, damage to the pulse output transistors from excessive loading is prevented.



PULSE GENERATOR
VELONEX
Model 220

Fig. 1
BLOCK DIAGRAM

VELONEX
Div. of Pulse Engineering, Inc.
560 Robert Avenue
Santa Clara, California

CAPACITORS

C1	.1uf	75V	CRL Disc		
C2	100pf	500V	Arco DM-15-101		5%
C3	1.5uf	200V	West - CAP	WF 70J 2155	5%
C4	.47uf	200V	West - "	WF 70J 2474	5%
C5	.15uf	200V	West - "	WF 70J 2154	5%
C6	.047uf	200V	West - "	WR 70J 2473	5%
C7	.015uf	200V	West - "	WR 70J 2153	5%
C8	.0047uf	100V	West - "	WR 68J 1472	5%
C9	.0015uf	100V	West - "	WR 68J 1152	5%
C10	390pf	500V	Arco DM-15-391		5%
C11	50pf	500V	Arco DM-15-500		5%
C12	.1uf	75V	CRL Disc		
C13	4uf	25V	Sprague TE 1201.2		
* C13 consists of 2 capacitors 4uf (C13 and C82) connected back to back					
C14	.1uf	10V	CRL Disc		
C15	.1uf	10V	CRL Disc		
C16	68pf	500V	Arco DM-15-680		5%
C17	68pf	500V	Arco DM-15-680		5%
C18	.1uf	10V	CRL Disc		
C19	.1uf	10V	CRL Disc		
C20	47pf	500V	Arco DM-15-470		5%
C21	.1uf	75V	CRL Disc		
C22	.1uf	75V	CRL Disc		
C23	47pf	500V	Arco DM-15-470		5%
C24	10uf	10V	Sprague TE 1114		
C25	.1uf	10V	CRL Disc		
C26	.1uf	10V	CRL Disc		
C27	68pf	500V	Arco DM-15-470		5%
C28	75pf	500V	Arco DM-15-470		5%
C29	330pf	500V	Arco DM-15-271		5%
C30	.001uf	100V	West - CAP	WR 68J 1102	5%
C31	.0033uf	100V	West - "	WR 68J 1332	5%
C32	.01uf	200V	West - "	WR 70J 2103	5%
C33	.033uf	200V	West - "	WR 70J 2333	5%
C34	.1uf	200V	West - "	WF 70J 2104	5%
C35	.33uf	200V	West - "	WF 70J 2334	5%
C36	.1uf	10V	CRL Disc		
C37	47pf	500V	Arco DM-15-470		5%
C38	10uf	10V	Sprague TE 1114		
C39	.1uf	10V	CRL Disc		
C40	.1uf	10V	CRL Disc		

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CAPACITORS CON'T.

C41	47pf	500V	Arco DM-15-470	5%
C42	47pf	500V	Arco DM-15-470	5%
C43	270pf	500V	Arco DM-15-271	5%
C44	1000pf	100V	West - CAP WR 68J 1102	5%
C45	3300pf	100V	West - " WR 68J 1332	5%
C46	.01uf	200V	West - " WR 70J 2103	5%
C47	.033uf	200V	West - " WR 70J 2333	5%
C48	.1uf	200V	West - " WF 70J 2104	5%
C49	.33uf	200V	West - " WF 70J 2334	5%
C50	.1uf	10V	CRL Disc	
C51	27uf	20V	Gen. Instrument 27M20V	
C52	.01uf	100V	Arco type PE	5%
C53	.1uf	10V	CRL Disc	
C54	120pf	500V	Arco DM-15	5%
C55	.1uf	10V	CRL Disc	
C56	680pf	300V	Arco DM-15	5%
C57	15uf	50V	Sprague TE1304.2	
C58	.47uf	50V	West - CAP WS 4M 474	
C59	25uf	25V	Sprague TE1207	
C60	.01uf	100V	Arco Type PE	5%
C61	.1uf	10V	CRL Disc	
C62	120pf	500V	Arco DM-15-121	5%
C63	680pf	300V	Arco DM-15-681	5%
C64	.1uf	10V	CRL Disc	
C65	.47uf	50V	West - CAP WS 4M 474	20%
C66	15uf	50V	Sprague TE1304.2	
C67	1250uf	50V	Sangamo PLPS-063	
C68	1250uf	25V	Sangamo PLPS-063	
C69	1000uf	25V	Mallory PFP	
C70	1000uf	25V	Mallory PFP	
C71	500uf	25V	Mallory PFP	
C72	50uf	50V	Gen. Instrument ABL 3970	
C73	50uf	50V	Gen. Instrument ABL 3970	
C74	100uf	25V	Gen. Instrument ABL 3962	
C75	100uf	25V	Gen. Instrument ABL 3962	
C76	1250uf	50V	Sangamo PLPS-063	
C77	1250uf	50V	Sangamo PLPS-063	
C78	500uf	25V	Mallory PFP	
C79	1uf	50V	Sprague TE1300	
C80	100uf	50V	Gen. Instrument ABL 4171	
C81	2uf	50V	Sprague TE 1301	
C82	4uf	25V	Sprague TE 1201.2	
C83	.1uf	10V	CRL Disc	
C84	.1uf	75V	CRL Disc	

VELONEX
Div. of Pulse Engineering, Inc.
560 Robert Avenue
Santa Clara, California

PARTS LIST MODEL 220

RESISTORS

R1	2.2K	.5W	5%	Composition
R2	5.6K	.5W	5%	Composition
R3	470	.5W	5%	Composition
R4	2.2K	.5W	5%	Composition
R5	4.7K	.5W	5%	Composition
R6	4.7K	.5W	5%	Composition
R7	50K	2W	10%	Comp. Potentiometer AB CMU - 5031
R8	3.3K	.5W	5%	Composition
R9	330	.5W	5%	Composition
R10	51K	.5W	5%	Composition
R11	4.7K	.5W	5%	Composition
R12	470	.5W	5%	Composition
R13	33	.5W	5%	Composition
R14	6.8K	.5W	5%	Composition
R15	4.7K	.5W	5%	Composition
R16	330	.5W	5%	Composition
R17	680	.5W	5%	Composition
R18	330	.5W	5%	Composition
R19	1K	.5W	5%	Composition
R20	68	.5W	5%	Composition
R21	2.2K	.5W	5%	Composition
R22	1K	.5W	5%	Composition
R23	100	.5W	5%	Composition
R24	470	.5W	5%	Composition
R25	39	.5W	5%	Composition
R26	620	.5W	5%	Composition
R27	390	.5W	5%	Composition
R28	1K	.5W	5%	Composition
R29	220	.5W	5%	Composition
R30	330	.5W	5%	Composition
R31	1.2K	.5W	5%	Composition
R32	47	.5W	5%	Composition
R33	22	.5W	5%	Composition
R34	240	.5W	5%	Composition
R35	22	.5W	5%	Composition
R36	5K	2W	10%	Compos. Pot. AB - CMU - 5021
R37	1.5K	.5W	5%	Composition
R38	220	.5W	5%	Composition
R39	100	.5W	5%	Composition
R40	120	.5W	5%	Composition

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560 Robert Avenue
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RESISTORS CON'T.

R41	620	.5W	5%	Composition
R42	390	.5W	5%	Composition
R43	1K	.5W	5%	Composition
R44	220	.5W	5%	Composition
R45	330	.5W	5%	Composition
R46	1.2K	.5W	5%	Composition
R47	47	.5W	5%	Composition
R48	22	.5W	5%	Composition
R49	240	.5W	5%	Composition
R50	22	.5W	5%	Composition
R51	5K	2W	10%	Composition Pot AB - CMU - 5021
R52	1.5K	.5W	5%	Composition
R53	220	.5W	5%	Composition
R54	100	.5W	5%	Composition
R55	120	.5W	5%	Composition
R56	10K	.5W	5%	Composition
R57	470	.5W	5%	Composition
R58	1.2K	.5W	5%	Composition
R59	22K	.5W	5%	Composition
R60	100	.5W	5%	Composition
R61	1.2K	.5W	5%	Composition
R62	4.7K	.5W	5%	Composition
R63	680	2W	5%	Composition
R64	680	2W	5%	Composition
R65	1K	.5W	5%	Composition
R66	10K	.5W	5%	Composition
R67	470	.5W	5%	Composition
R68	1.2K	.5W	5%	Composition
R69	22K	.5W	5%	Composition
R70	100	.5W	5%	Composition
R71	4.7K	.5W	5%	Composition
R72	1.2K	.5W	5%	Composition
R73	470	2W	5%	Composition
R74	470	2W	5%	Composition
R75	1K	.5W	5%	Composition
R76	43	2W	5%	Composition
R77	36	2W	5%	Composition
R78	27	1W	5%	Composition
R79	27	.5W	5%	Composition
R80	36	.5W	5%	Composition
R81	27	.5W	5%	Composition
R82	27	.5W	5%	Composition
R83	36	.5W	5%	Composition

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RESISTORS CON'T.

R84	27	.5W	5%	Composition
R85	22K	.5W	5%	Composition
R86	10K	.5W	5%	Composition
R87	1K	.5W	5%	Composition
R88	22K	.5W	5%	Composition
R89	22K	.5W	5%	Composition
R90	12K	.5W	5%	Composition
R91	1K	.5W	5%	Composition
R92	1K	.5W	5%	Composition
R93	1K	.5W	5%	Composition
R94	22K	.5W	5%	Composition
R95	330	.5W	5%	Composition
R96	2.2K	.5W	5%	Composition
R97	330	.5W	5%	Composition
R98	2.2K	.5W	5%	Composition
R99	4.7K	.5W	5%	Composition
R100	4.7K	.5W	5%	Composition
R101	220	.5W	5%	Composition
R102	1K	.5W	5%	Composition
R103	1/2	2W	10%	Wire IRC BWH
R104	820	.5W	5%	Composition
R105	100	2W	10%	PC Trim Pot CTS-BL 247668 Series 115
R106	180	.5W	5%	Composition
R107	1	2W	10%	Wire IRC BWH
R108	1K	2W	10%	Composition
R109	470	.5W	5%	Wire IRC BWH
R110	330	.5W	5%	Potentiometer OHMITE-AB-CMU 1021
R111	100	2W	10%	Composition
R112	100	.5W	5%	Composition
R113	1.5K	1W	5%	
R114	2.2	2W	10%	Composition
R115	680	.5W	5%	Composition
R116	5K	2W	10%	Wire IRC BWH
R117	680	.5W	5%	Composition
R118	8.2K	.5W	5%	Potentiometer OHMITE-AB-CMU 5021
R119	1K	2W	5%	Composition
R120	27	2W	5%	Composition
R121	330	.5W	5%	Composition
R122	47	.5W	5%	Composition
R123	1.5K	1W	5%	Composition
R124	1.2K	.5W	5%	Composition

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560 Robert Avenue
Santa Clara, California

DIODES

D1	IN3604	General Electric
D2	IN3604	General Electric
D3	IN3604	General Electric
D4	IN3604	General Electric
D5	IN3604	General Electric
D6	IN3604	General Electric
D7	IN3604	General Electric
D8	IN3604	General Electric
D9	IN3604	General Electric
D10	IN3604	General Electric
D11	IN3604	General Electric
D12	IN3604	General Electric
D13	IN3604	General Electric
D14	IN3604	General Electric
D15	IN3604	General Electric
D16	IN3730	Raytheon
D17	IN3604	General Electric
D18	IN3604	General Electric
D19	IN3604	General Electric
D20	IN3604	General Electric
D21	IN3193	RCA
D22	IN3193	RCA
D23	IN3193	RCA
D24	IN3193	RCA
D25	IN3193	RCA
D26	IN3193	RCA
D27	IN3193	RCA
D28	IN3193	RCA
D29	IN3193	RCA
D30	IN3193	RCA
D31	IN3193	RCA
D32	IN3193	RCA
D33	IN3193	RCA
D34	IN3193	RCA
D35	IN3604	RCA
D36	IN3604	RCA

ZENERS

Z1	IN3016	Transitron
Z2	IN753A	Transitron

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TRANSFORMERS

TR1	PE-4961 EF71 50uh 4:1:2
TR2	Triad Power Transformer 69204

INDUCTORS

L1	1uH	Miller	9310-12	10%
L2	2.2uH	Miller	9310-20	10%

SWITCHES

S1 S2	2 Pole	2 Section	12 Pos.	Oak 399 - 470 JC
S3	1 Pole	1 Section	12 Pos.	Oak 399 - 468 JC
S4	1 Pole	1 Section	12 Pos.	Oak 399 - 468 JC
S5 S6 S7 S8 S9 S10	6 Pole	3 Section	6 Pos.	Oak 399 - 468 JC
S11	Power Toggle Switch Arrow H & H 86994 - N			

FUSES

F1	1-1/2 A SB	3 AG
F2	1/2 A	3 AG
F3	3/4 A	3 AG
F4	3/10 A	3 AG
F5	3/10 A	3 AG

HEAT SINKS

3	Heat Sink	MS-15	Motorola
2	Heat Sink	TXS-032-047	1 ERC
2	" "	TXBF-032-025B	1 ERC

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TRANSISTORS

T1	2N2221	Motorola
T2	2N2221	Motorola
T3	2N2221	Motorola
T4	2N708	RCA
T5	2N708	RCA
T6	2N708	RCA
T7	2N2221	Motorola
T8	2N2221	Motorola
T9	2N1304	Texas Instruments
T10	2N708	RCA
T11	2N708	RCA
T12	2N708	RCA
T13	2N1204	Motorola
T14	2N1304	Texas Instruments
T15	2N708	RCA
T16	2N708	RCA
T17	2N708	RCA
T18	2N1204	Motorola
T19	2N1204	Motorola
T20	2N2221	Motorola
T21	2N2710	Philco
T22	2N2410	Texas Instrument
T23	2N2410	Texas Instrument
T24	2N2221	Motorola
T25	2N1204	Motorola
T26	2N1495	Philco
T27	2N1495	Philco
T28	2N404A	Texas Instruments
T29	2N404A	Texas Instruments
T30	2N404A	Texas Instruments
T31	2N404	Texas Instruments
T32	2N404A	Texas Instruments
T33	2N404A	Texas Instruments
T34	2N404	Texas Instruments
T35	2N404	Texas Instruments
T36	2N2082	Motorola
T37	2N1540	Motorola
T38	2N1540	Motorola
T39	2N1540	Motorola
T40	2N2082	Motorola
T41	2N404A	Texas Instruments
T42	2N1700	RCA
T43	2N2082	Motorola
T44	2N2710	Philco

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NEON INDICATOR LIGHT

PL1	Colorlite	858-R

KNOBS

Small Knob	70-2-2G	Raytheon	Black Matte Finish
Knob With Skirted Dial	70-3-2G	Raytheon	Black Matte Finish

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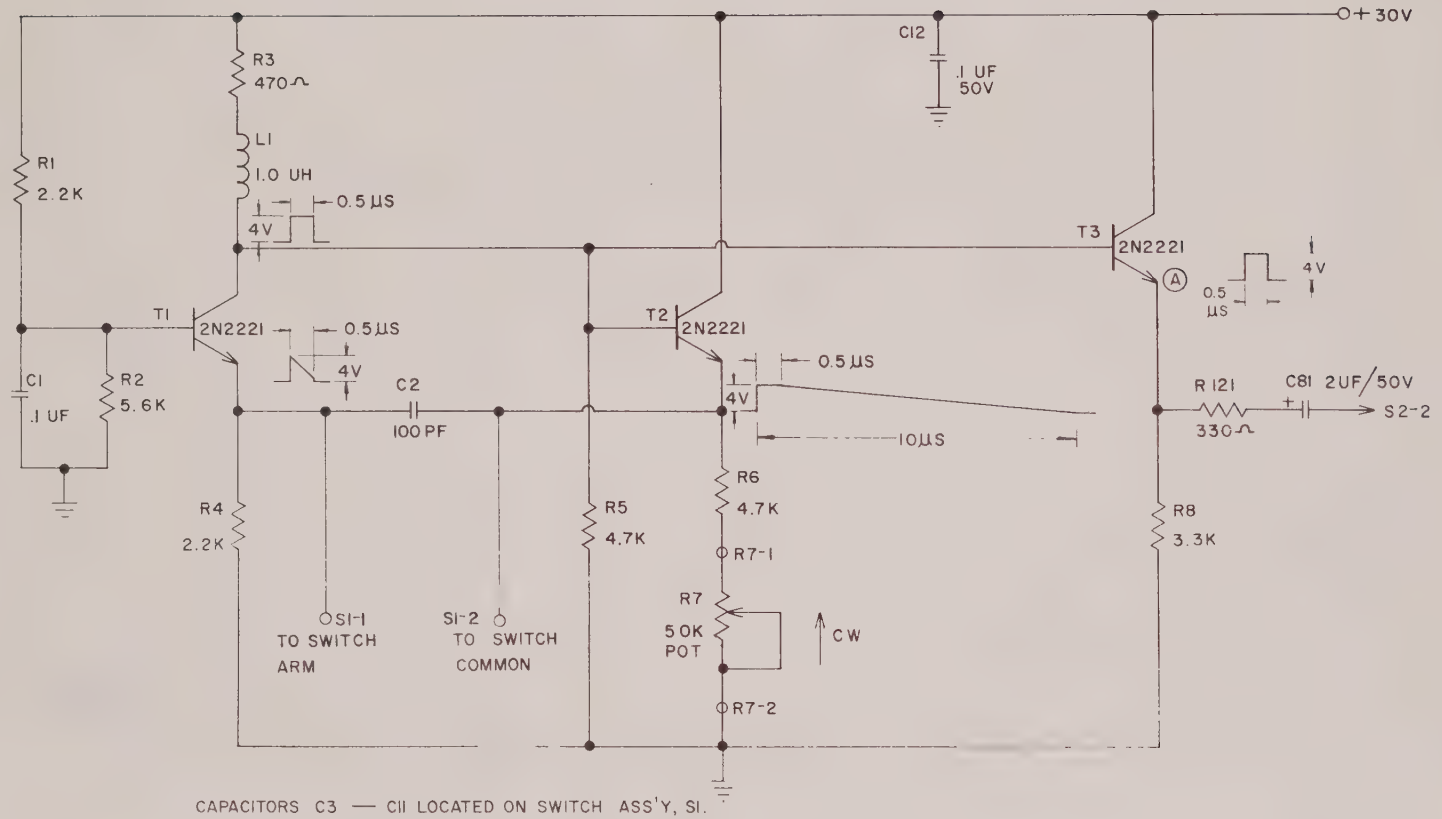
All wave forms on sheet 1 through 9 are taken with a Tektronix 545A scope under following control settings and loading conditions:

Repetition Rate	100KC
Pulse Delay	Minimum
Pulse Width	1us
Attenuator Setting	1
Positive & Negative Output Amplitude	10V

Loading Conditions:

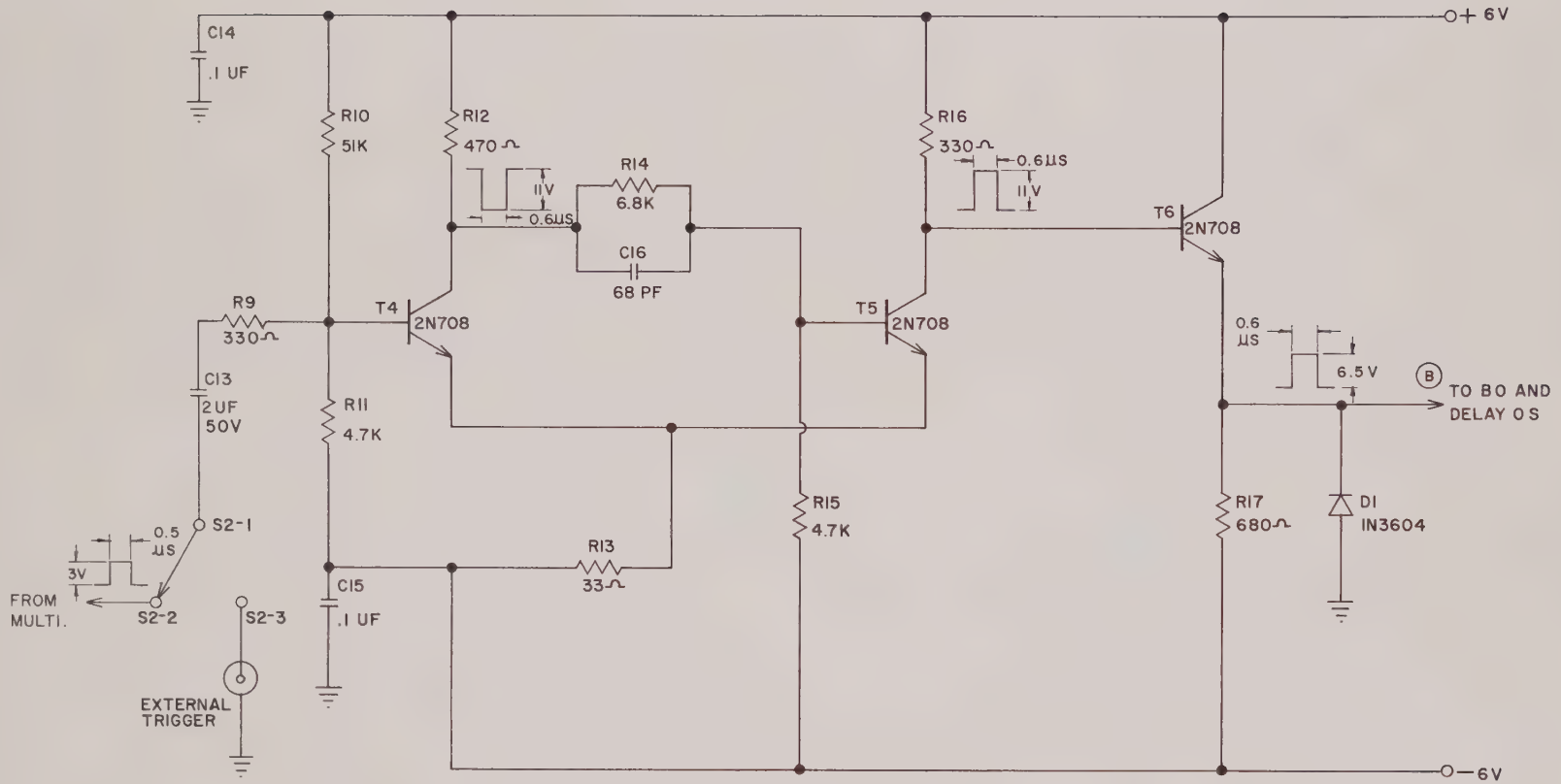
Positive Output	Load 50 Ω
Negative Output	Load 50 Ω
Trigger Output	Load 50 Ω



CAPACITORS C3 — C11 LOCATED ON SWITCH ASS'Y, S1.
ALL RESISTORS ARE 5% AND 1/2W IF NOT NOTED OTHERWISE
S1 IS GANGED WITH S2

PULSE GENERATOR
MULTIVIBRATOR

VELONEX
div. of PULSE ENGINEERING
Model 220 Date DEC 14, 1962
Sheet 1 of 9

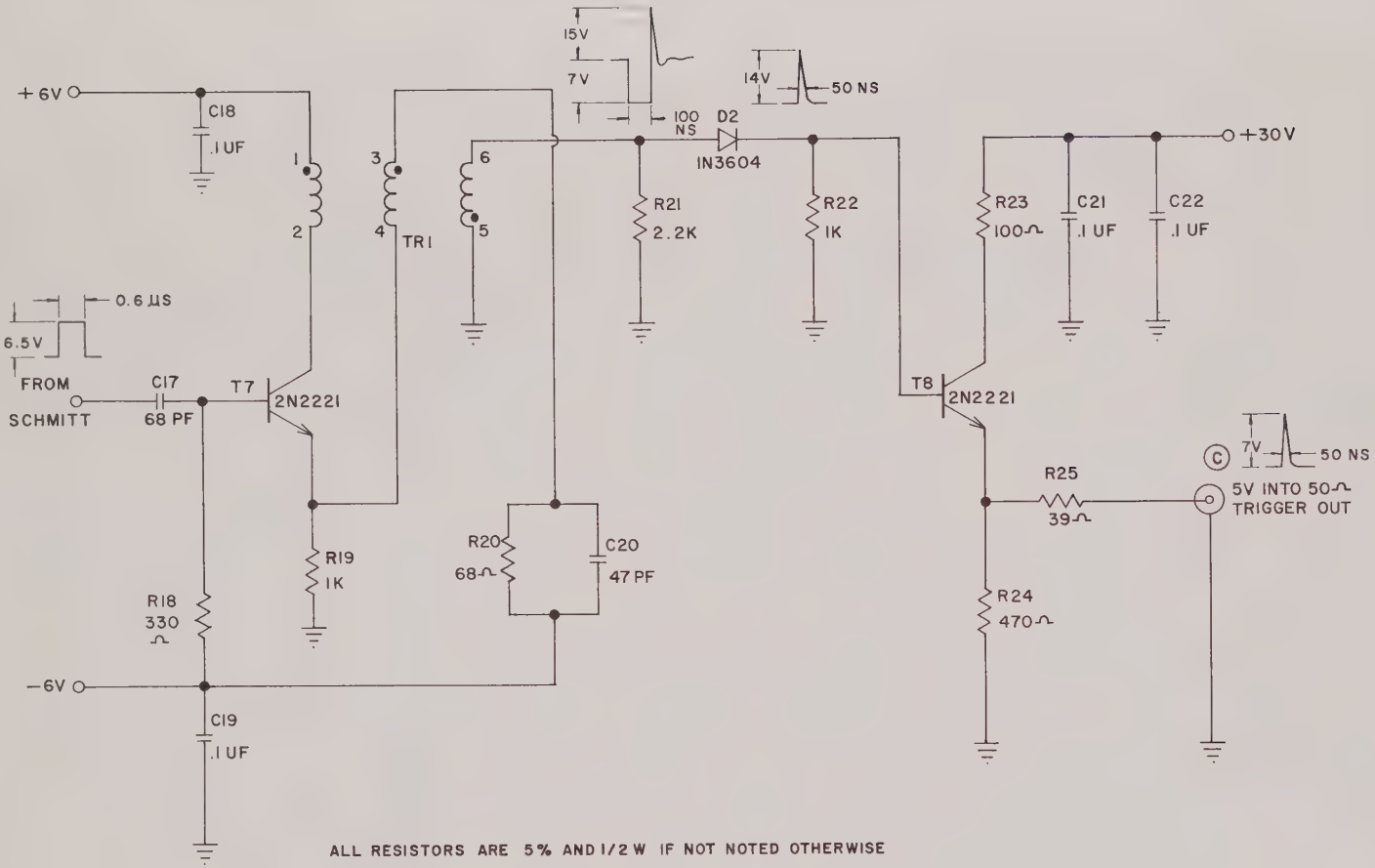


ALL RESISTORS ARE 5% AND 1/2 W IF NOT NOTED OTHERWISE

PULSE GENERATOR
SCHMITT TRIGGER

VELONEX
div. of PULSE ENGINEERING
Model 220 Date DEC. 14, 1962
Sheet 2 of 9

220-317

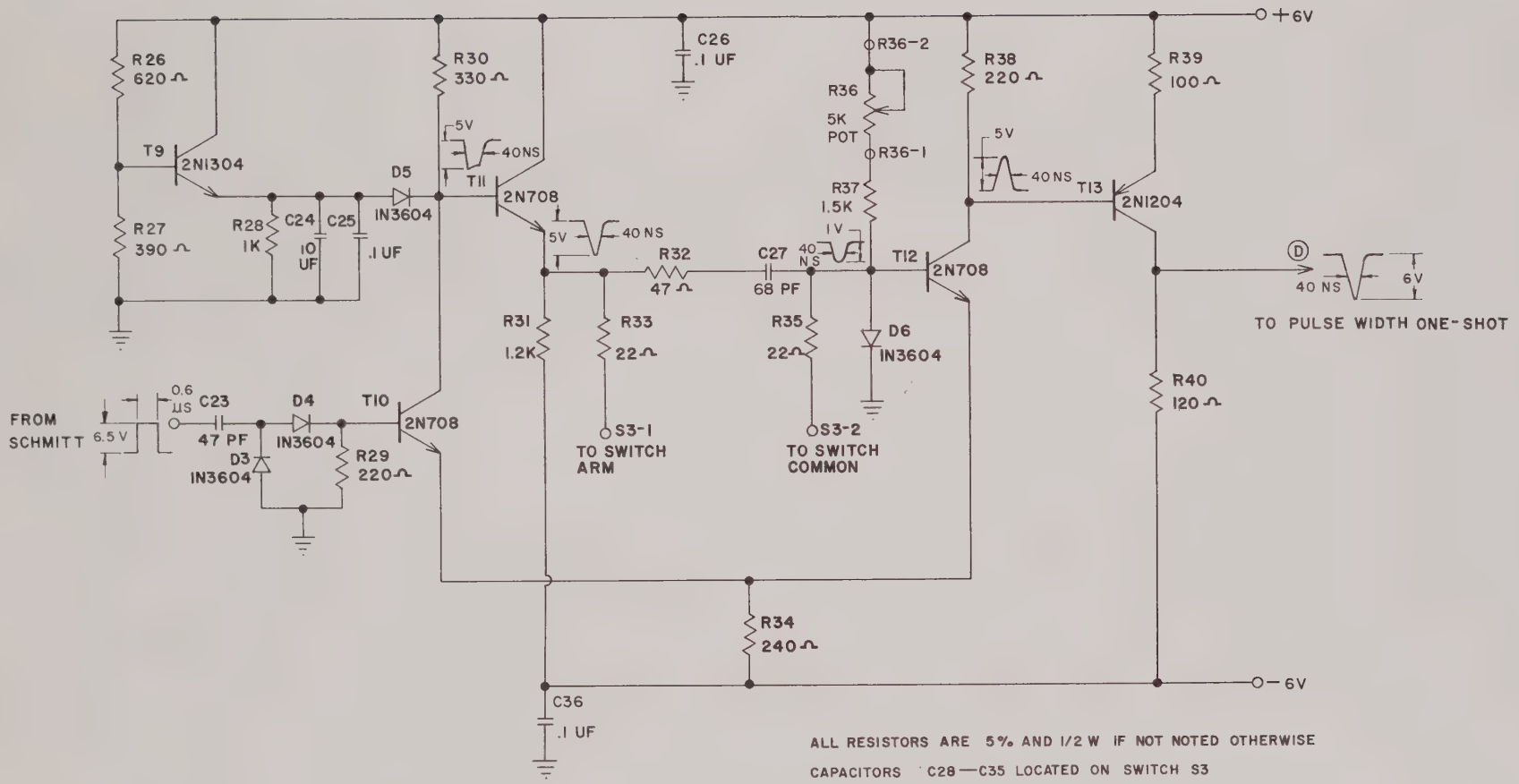


ALL RESISTORS ARE 5% AND 1/2 W IF NOT NOTED OTHERWISE

PULSE GENERATOR
DELAYED EXTERNAL
TRIGGER B. O.

VELONEX
div. of PULSE ENGINEERING
Model 220 Date DEC. 14, 1962
Sheet 3 of 9

220-317



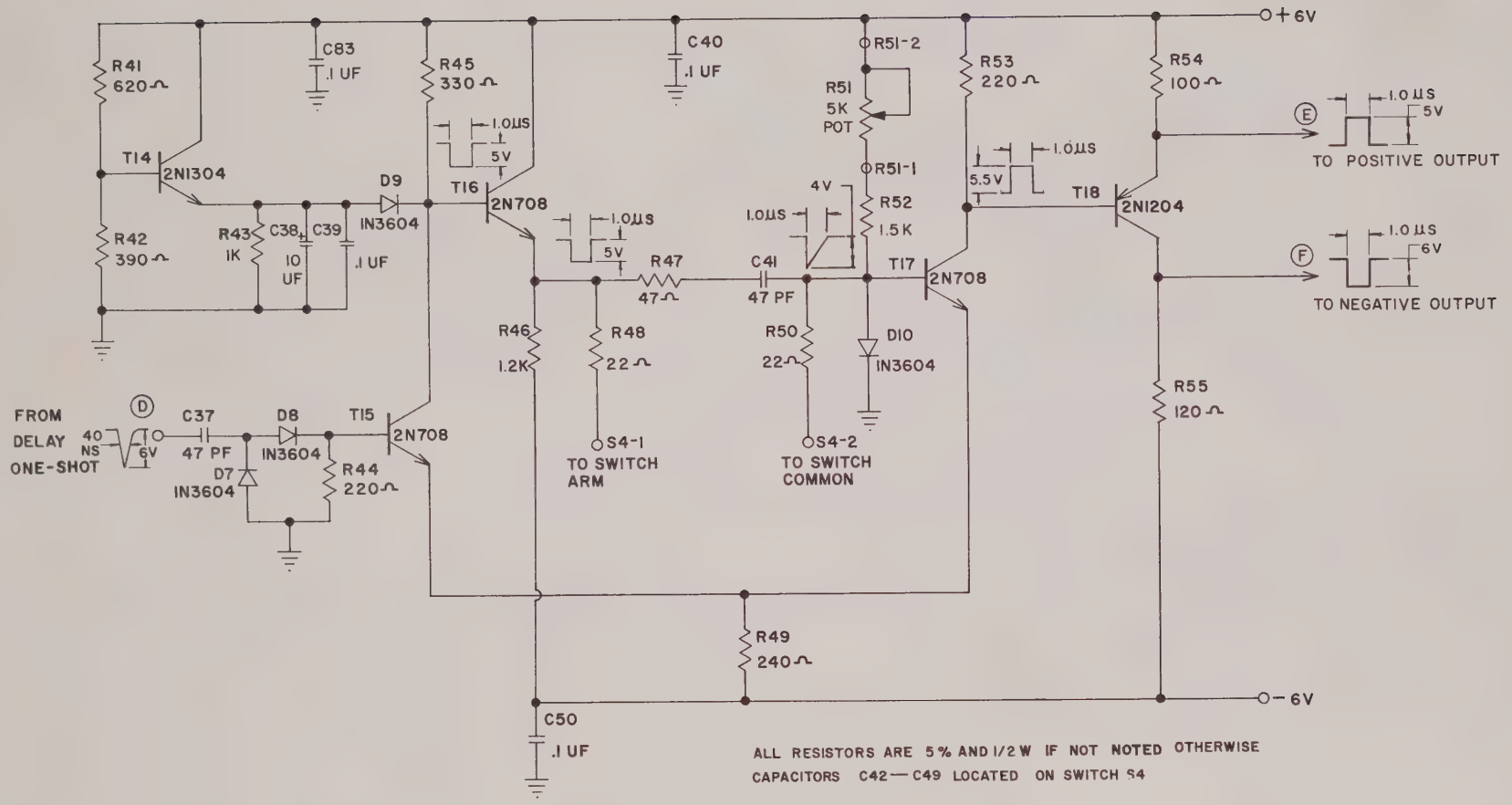
PULSE GENERATOR
DELAY ONE-SHOT

VELONEX
div. of PULSE ENGINEERING

Model 220 Date DEC. 12, 1962

Sheet 4 of 9

220-317

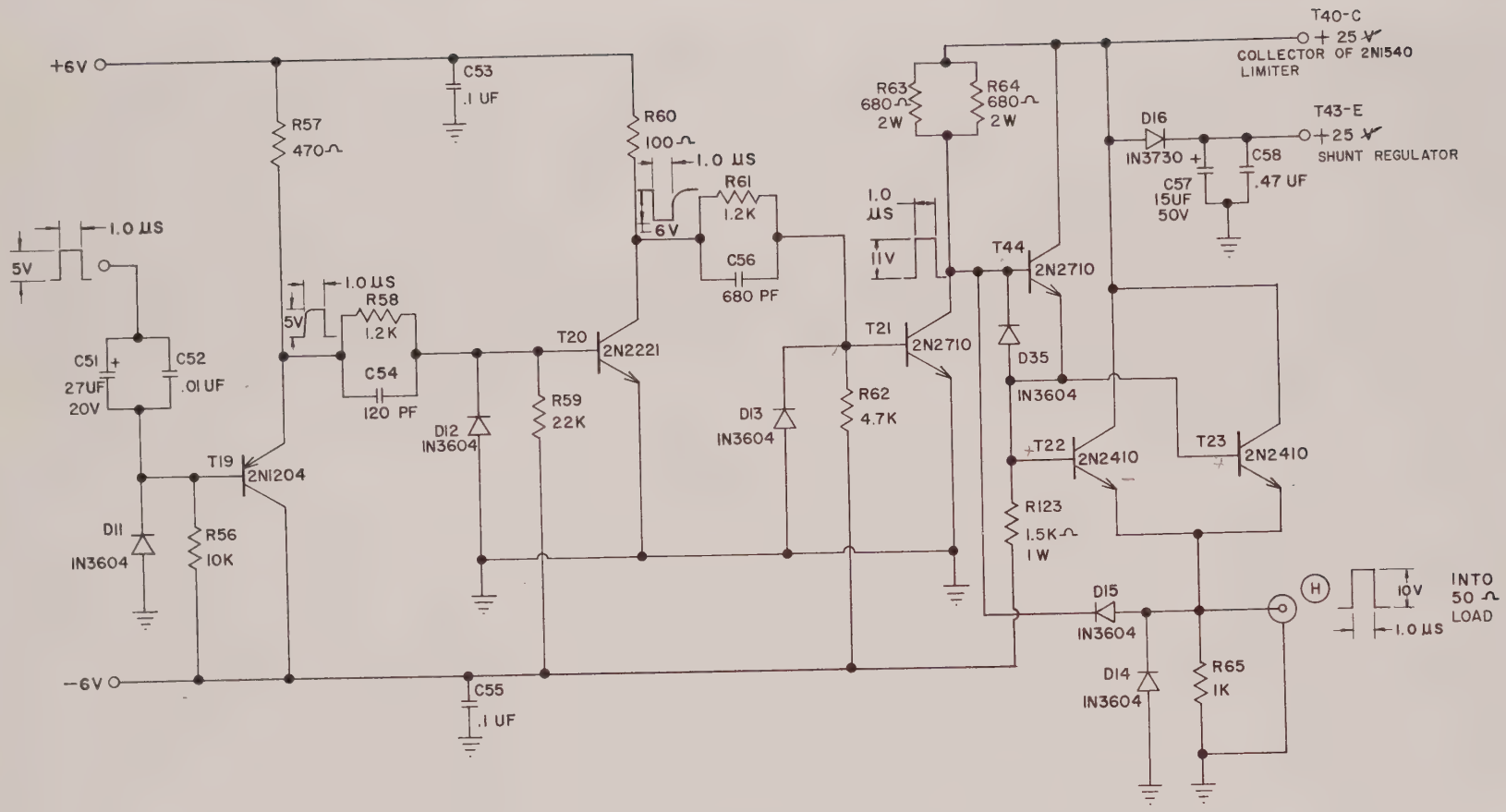


PULSE GENERATOR

PULSE WIDTH ONE-SHOT

220-317

VELONEX
div. of PULSE ENGINEERING
Model 220 Date DEC. 12, 1962
Sheet 5 of 9

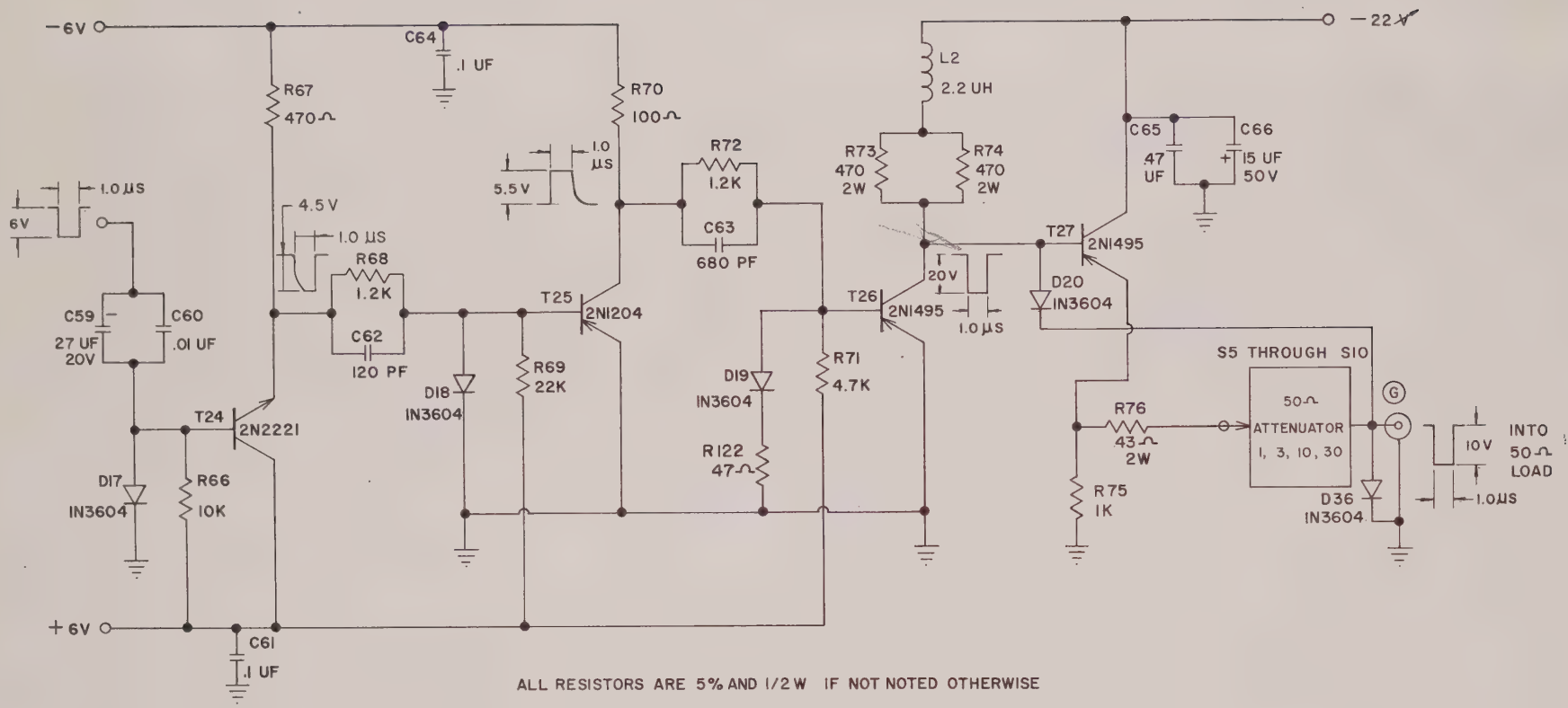


ALL RESISTORS ARE 5% AND 1/2 W IF NOT NOTED OTHERWISE

PULSE GENERATOR
POSITIVE OUTPUT PULSE

VELONEX
div. of PULSE ENGINEERING
Model 220 Date DEC. 12, 1962
Sheet 6 of 9

220-316

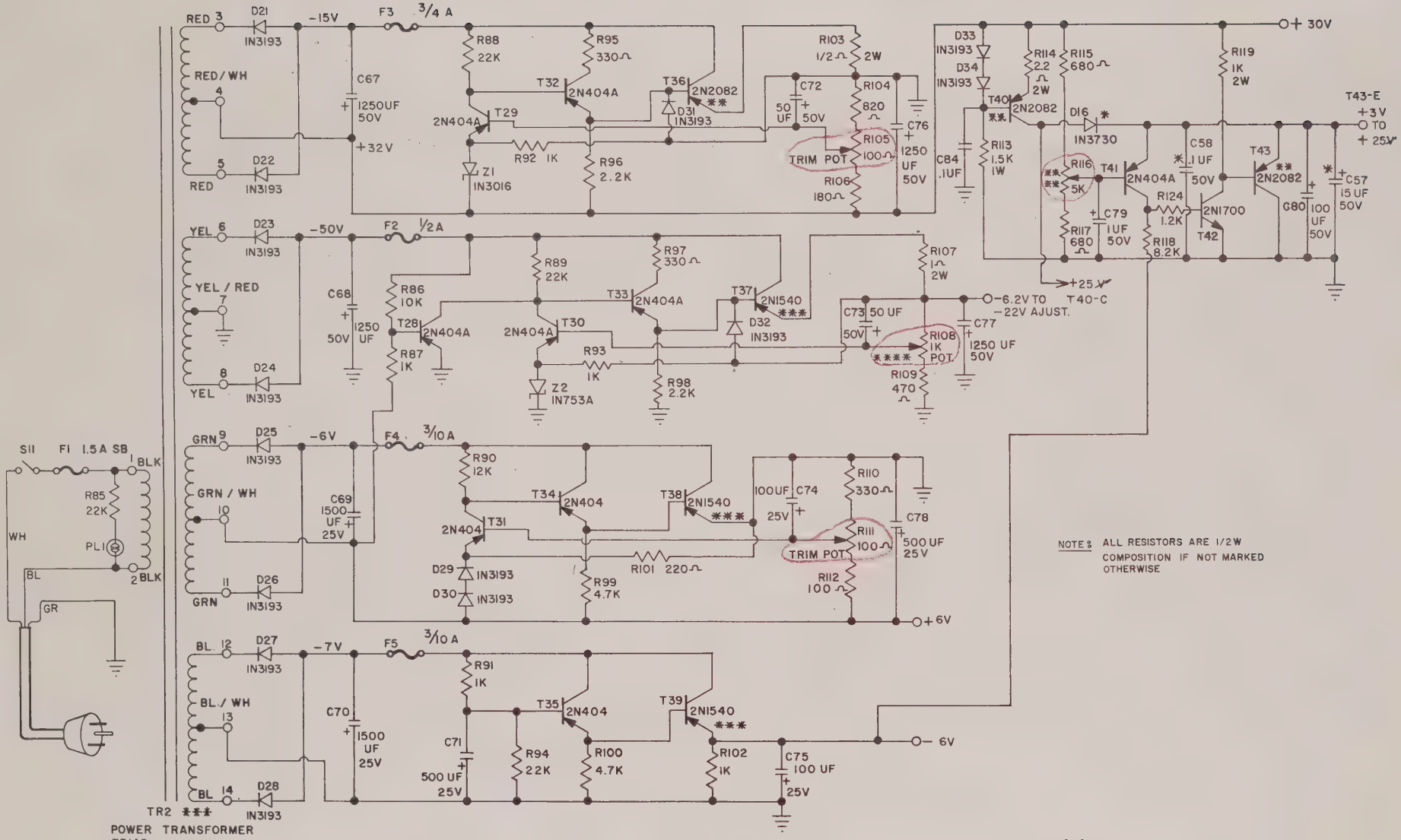


ALL RESISTORS ARE 5% AND 1/2 W IF NOT NOTED OTHERWISE

PULSE GENERATOR
NEGATIVE OUTPUT PULSE

VELONEX
div of PULSE ENGINEERING
Model 220 Date Dec. 13, 1962
Sheet 7 of 9

220-324



NOTE: ALL RESISTORS ARE 1/2W COMPOSITION IF NOT MARKED OTHERWISE

COMPONENTS MARKED WITH * ARE LOCATED ON LOGIC BOARD
COMPONENTS MARKED WITH ** ARE LOCATED ON REAR PANEL (HEATSINK)
COMPONENTS MARKED WITH *** ARE LOCATED ON CHASSIS
COMPONENTS MARKED WITH 4* ARE LOCATED ON FRONT PANEL

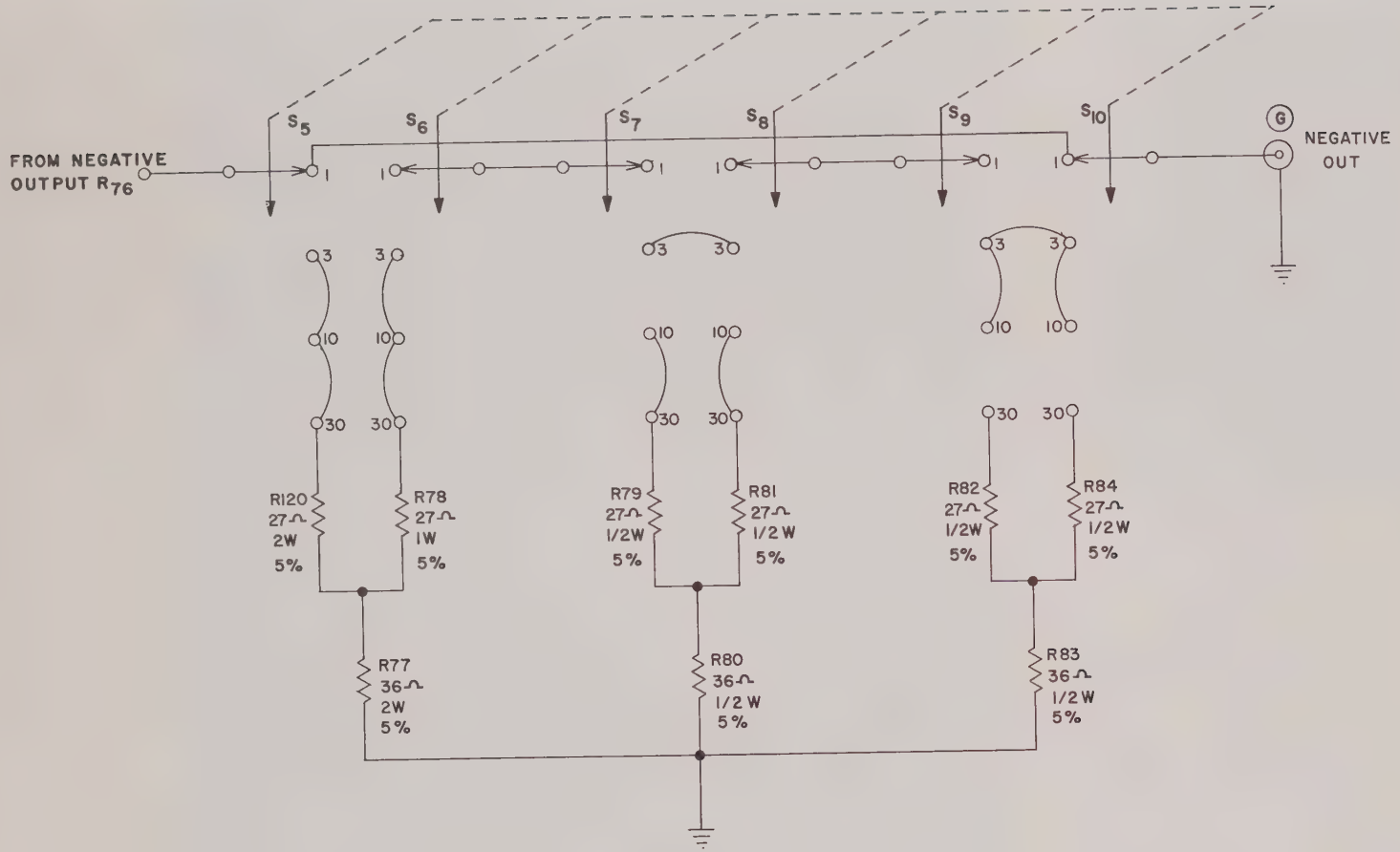
PULSE GENERATOR
POWER SUPPLY

VELONEX
div of PULSE ENGINEERING

Model 220 Date DEC. 12, 1962

Sheet 8 of 9

220-317



PULSE GENERATOR
1,3,10,30 ATTENUATOR 50Ω

VELONEX
div of PULSE ENGINEERING
Model 220 Date DEC. 14, 1962
Sheet 9 of 9

220-317

The VELONEX Model 103 Accessory Kit provides the hardware and useful attachments to conveniently connect, control and expand the usefulness of your VELONEX Model 215 Ramp/Pulse Generator and/or your VELONEX Model 220 Pulse Generator. Included are the following:

One (1) 48" RG-58 A/U cable with series 31 BNC connectors at each end.
Two (2) 18" RG-58 A/U cable with series 31 BNC connectors at each end.
One (1) test load, consisting of 1% 50 & 100 resistors and switch.
One (1) component clip.
One set of three (3) plug-in transformers as follows:
- One (1) 1:1 inverting for short pulses and 700V dc isolation.
- One (1) 2:1 non-inverting for short pulses 700V dc isolation.
- One (1) 1:2 non-inverting for short pulses 700V dc isolation.

One (1) pilot light 115V ac.
One (1) set of fuses for 215 or 220.
Two (2) "Y" clip lead sets.
One (1) UHF-BNC adapter.
One (1) GR-BNC adapter.

Price Complete: $170.00

2/1963 All data subject to change without notice.

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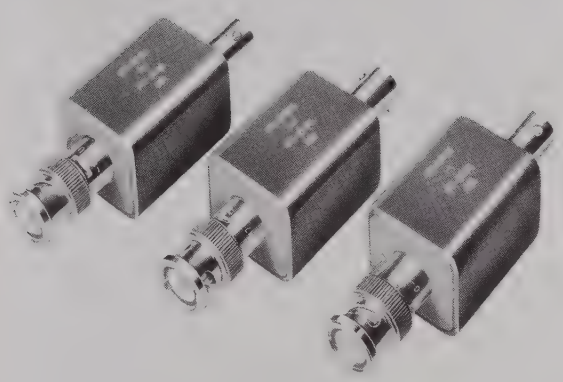
velonex



Plug-in output pulse transformers selected from the Pulse Engineering Catalog #204 may be specified in the above configuration and offer an infinite variety of impedance matching, wave shaping, high voltage and DC isolation.

How to order:

1. Select two (2) winding transformer from P.E. Cat. #204. Three (3) winding transformers available but special.
2. Note turns ratio open circuit inductance etc. and order by P.E. Cat. number and specify Velonex Model 104.

Price Complete: $29.00

2/1963 All data subject to change without notice.

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velonex

THIS IS THE INSTRUMENT THAT HAS MADE EVERY CONVENTIONAL PULSE GENERATOR OBSOLETE ... IN THE LABORATORY OR ON THE PRODUCTION LINE.

TESTS ARE FASTER because set-up time and adjustment time is reduced.

TESTS ARE MORE ACCURATE because of the new ramp method and because the instrument yields a droopless pulse reading

TESTS ARE REPRODUCIBLE — clean, sharp accurate readings are readily recorded.

OUTPUT WAVEFORM IS MORE CONSISTENT because of 1 ohm generator internal impedance.

FEWER SERVICE PROBLEMS with this completely transistorized instrument.

Send for complete details. Price: $1265.00

THE VELONEX RAMP/PULSE GENERATOR

Almost every circuit designer has encountered the problem of the pulse transformer that "meets the specs"... but doesn't do the job. One primary reason: the lack of a really accurate method of measuring pulse inductance.

To predict and control pulse droop in transformer coupled circuits and pulse width in certain types of transistor and vacuum tube regenerative blocking oscillator circuits, you need accurate knowledge of the coupling transformer's pulse inductance. Attempts to perform this measurement on sine wave impedance bridges have yielded varying results, depending on the type of core (gapped or ungapped), the type of core material, the core's previous magnetic history. The inconsistency is due to the small signal incremental nature of the typical alternating current impedance bridge measurement. The inductance indicated by this type of instrument is a function of the slope and location of the minor hysteresis loop traversed by the core flux. In most pulse applications, rather large changes of flux are encountered in which the excursions are unidirectional from an established remnant flux point. The slope, shape and location of the pulse hysteresis loop can be radically different from its sine wave counterpart.

THE METHOD of measuring pulse inductance, made possible by the RAMP/PULSE GENERATOR, applies a known current ramp to the unknown coil with resulting peak induced voltage. This method is not only much simpler; it is also far more accurate, since the peak pulse inductance value is related to a simple peak voltage amplitude measurement. Second, the onset of core saturation is easily observed. Third, pulse core loss may be determined by a simple calculation if desired. Fourth, the annoying parasitic oscillations that often occur on the current ramp during magnetizing current measurements are eliminated.

THE INSTRUMENT that makes possible this type of measurement is the RAMP/PULSE GENERATOR. By using it, you can measure *pulse inductance* accurately in terms of an easily read peak induced voltage. This instrument also has a pulse voltage output for *magnetizing current* or *pulse droop* measurements. Its generator internal impedance in this mode of operation is approximately 1 ohm, thus producing virtually droopless voltage pulses. Measurement of *ET constant* is also simplified with the RAMP/PULSE GENERATOR.

SPECIFICATIONS

CURRENT RAMP OUTPUT

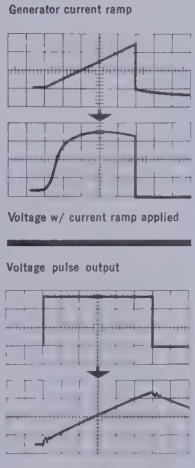
Ramp length ..... 1 to 1000 usec (3 ranges plus vernier)
Ramp amplitude ..... 0 to 250 ma (Continuously variable)
Back-up voltage ..... 25 volts, maximum
Repetition rate ..... 100 cps — 100 KC (3 ranges plus vernier)
Current monitor ..... 1 volt per 0.10 amps (negative)

PULSE VOLTAGE OUTPUT

Pulse width ..... 1 to 1000 usec (3 ranges plus vernier)
Pulse amplitude ..... 5 to 25 volts (continuously variable)
Pulse current ..... 250 ma
Repetition rate ..... 100 cps — 100 KC (3 ranges plus vernier)
Polarity ..... positive or negative
Source impedance ..... 1 ohm
Rise time ..... Approx. 20ns; 35ns maximum

GENERAL SPECIFICATIONS

Output D.C. ..... 0 v
Synchronized voltage ..... 5 volts positive
Duty cycle ..... 10% maximum (automatically limited)
Power consump. 115V, 50-1000 cps, 50 watts
Dimensions ... 17" wide, 13" deep, 5¾" high
Weight ..... approximately 15 lbs



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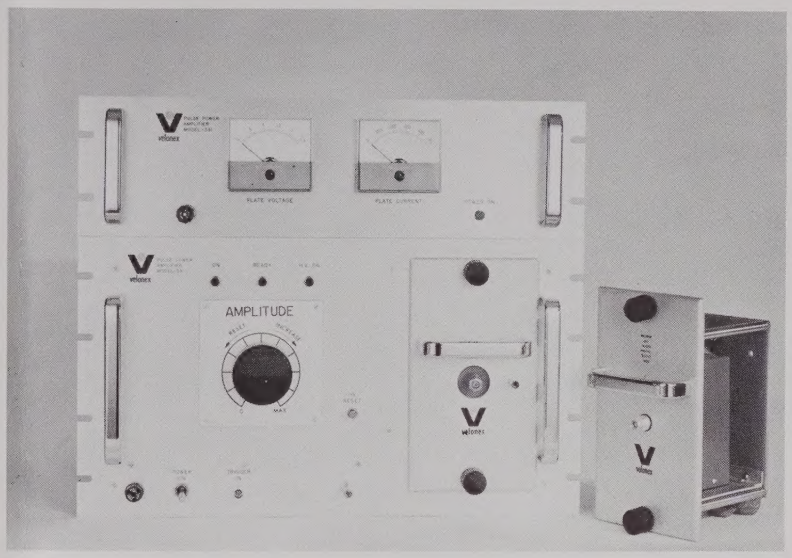

PULSES

- ★ High Voltage or High current
- ★ Fast rise time
- ★ Flexibility
- ★ Excellent wave form

The new VELONEX Model 330-331 is a versatile general purpose pulse amplifier/modulator which provides an excellent wave form at high power levels. Pulse amplitude, pulse width and repetition rate are continuously variable. With the use of output plug-ins, wide flexibility of output is achieved.

Applications for the Model 330-331 include pulsing of TWT's, magnetrons, klystrons, HF triodes, laser diodes and other high voltage or high current pulsed devices and circuits.

The output pulse is negative and continuously variable from 100 to 2000 volts into 400 ohms. With the use of type 12 output plug-ins, which incorporate pulse transformers, positive or negative pulses up to 20KV or 100 amps can be provided. For maximum power, load impedance matching is necessary. It is simple to select the type of plug-in for optimum load impedance matching. The source impedance of the unit is approximately 400 ohms, therefore, the ideal load without a plug-in is 400 ohms. For example, for a load of 100 ohms, one would select a 2:1 step-down plug-in. The maximum voltage then available across 100 ohms would be 1000v. Plug-ins are available for DC isolation up to 30KV.

HOW TO ORDER: Determine the impedance of your load. Select a suitable plug-in from VELONEX list of type 12 plug-ins available. Select a plug-in for positive or negative output pulse. Determine what range of pulse width is required. Pulse width ranges are: 0.1-1μsec, 1-10μsec, 10-30 μsec, 30-100μsec. For example, if the pulse width range required is 0.6μsec to 8μsec, one should specify 0.1-1μsec and 1-10μsec plug-ins. Since 1-10μsec is standard for the Type 11 interstage plug-ins, then a set of Type 11 plug-ins, 0.1-1μsec, should be ordered as well. Type 12 plug-ins should be selected corresponding to each pulse width range (See Type 12 plug-in bulletin).

It is helpful to specify load conditions pertinent to your application. For applications requiring higher power pulses, inquire about VELONEX Model 331A. For special requirements, please contact VELONEX or your local Sales Representative.

velonex / a division of pulse engineering, inc. / 560 robert avenue, santa clara, california / 244-7370 / twx 408-287-6570

velonex

SPECIFICATIONS

Peak power output		10 KW Max.
Peak voltage	Direct output with plug-in (1:10 step-up)	2.0 KV Max. 20 KV Max.
Peak current	Direct output with plug-in (20:1 step-down)	5 Amp. Max. 100 Amp. Max.
Rise and fall times		Less than 70ns into 400 ohms resistive for pulses less than 10μsec. wide.
	(Rise time typically 50ns for pulse widths of less than 10μsec into 400 ohms resistive load; typically 30ns for pulse widths of less than 1μsec)	
Pulse width, controlled externally		1-10μsec.
	Other ranges available: 0.1 - 1μsec. 10 - 30μsec 30 - 100μsec.	
Duty cycle		0.01 at 10 KW peak 0.02 at 7.5 KW peak 0.03 at 5 KW peak
Overshoot		Less than 5%
Output pulse droop		Less than 5%
Repetition rate, controlled externally		lcps - 100KC
Drive requirements	50 volts minimum pulse, having less than 30ns rise and fall time when operating into 27K resistive, with 30$\mu\mu$f capacitance.	
Delivery		Less than 30 days.
Price		
Model 330 Basic Unit		$2490.00
Type 11 Plug-in		$ 100.00 set
Type 12 Plug-in		$ 250.00 ea.
Model 220R Pulse Generator		$1180.00
Model 105 Single Pulse Generator		$ 62.50

For further information contact VELONEX or your local sales representative.

Data subject to change without notice.
August 1963.

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